Introduction

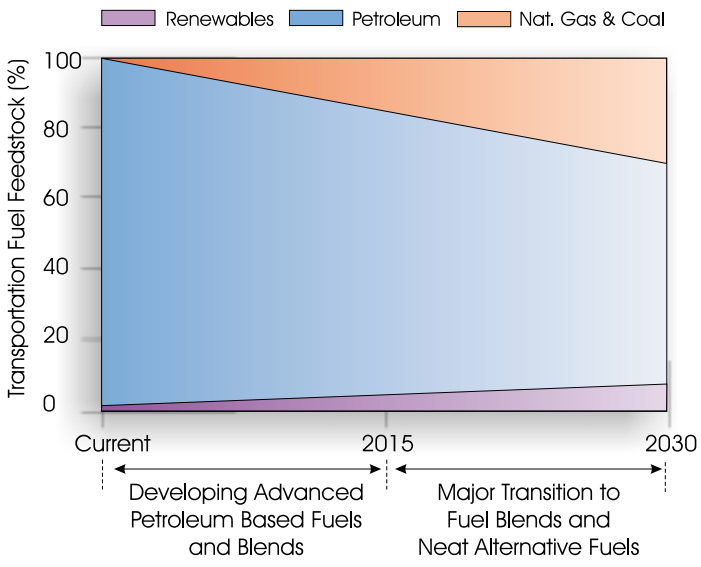
Providing our Nation with clean, plentiful transportation fuels for the 21st century presents enormous challenges. The availability of a clean and affordable energy supply for transportation is essential for sustaining economic growth, social stability, and public health. Major issues facing transportation include air pollution, emissions of greenhouse gases, and increasing reliance on imported oil. The DOE role is to promote the development of technologies that will provide our Nation with high-efficiency highway transportation power systems and a stable supply of clean and affordable transportation energy. As a vital element of its response to these challenges, DOE has initiated the comprehensive Ultra-Clean Transportation Fuels (UCTF) Program.

The UCTF Program encompasses research, development, and demonstration (RD&D) activities that will provide for near-term, mid-term, and longer-term results. In the near term, petroleum-based fuels will dominate the market; consequently, the Program will ensure that these fuels are compatible with emerging high-efficiency power system technologies under development in the Partnership for a New Generation of Vehicles (PNGV) and the 21st Century Truck initiatives. This will result in both dramatic decreases in emissions and significant increases in fuel economy. In the long term, other activities are included to facilitate a transition toward renewable and sustainable fuels.

The strategy of the UCTF Program is to make available a sustainable supply of ultra-clean transportation fuels consistent with projected changes in the characteristics of the Nation's fuel resources and to test, evaluate, and optimize advanced petroleum-based fuels in engines within the context of a systems approach (see Figure 1). The Program will develop advanced fuel production/

processing techniques that will enable advanced petroleum-based fuels to be producible and deliverable to the driving public in a cost-effective manner. In keeping with the mission of this Initiative, these fuels will be produced from a variety of domestic resources to include crude oil, refinery by-products, natural gas and coal, as well as renewable biomass. The utilization of these fuels will not require major changes to the Nation's existing liquid transportation fuels infrastructure. In this Program, natural gas is considered as a feedstock for the production of liquid transportation fuels. Plans for natural gas (i.e., pressurized gas) vehicles are not included.

Figure 1: Ultra-Clean Transportation Fuels Program Strategy



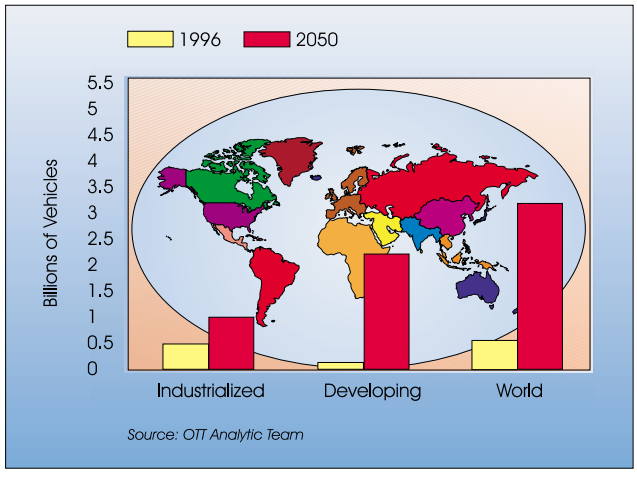
Issues

There are increasing national and global concerns regarding the energy demands and environmental impacts of highway transportation vehicles. The energy demand concerns, which pertain to both the magnitude of transportation energy required and dependence on foreign sources for transportation fuels or fuel feedstocks, have a major bearing on a nation's ***energy security***. The ***environmental concerns*** involve highway vehicle emissions that: (1) directly threaten the health of individuals that reside within a given metropolitan area or region of the country; and/or (2) induce atmospheric conditions which, in turn, produce climate changes that are potentially deleterious to the health of the overall populations and economies of the world.

Energy Security

The world's driving population, the vehicle population, and the vehicle-miles-traveled (VMT) per vehicle are rapidly expanding. In fact, world vehicle use is anticipated to quadruple in the next 50 years (see Figure 2). Given the fact that the global highway transportation fleet is almost totally dependent on petroleum-based fuels, the escalating demand being placed on the world's finite supply of petroleum is creating unprecedented levels of volatility in the availability and market value of transportation fuels. This volatility is a clear and present threat to the security of the United States because it jeopardizes this country's ability to transport the goods required to sustain its economic growth and preserve the degree of personal mobility essential to its citizens.

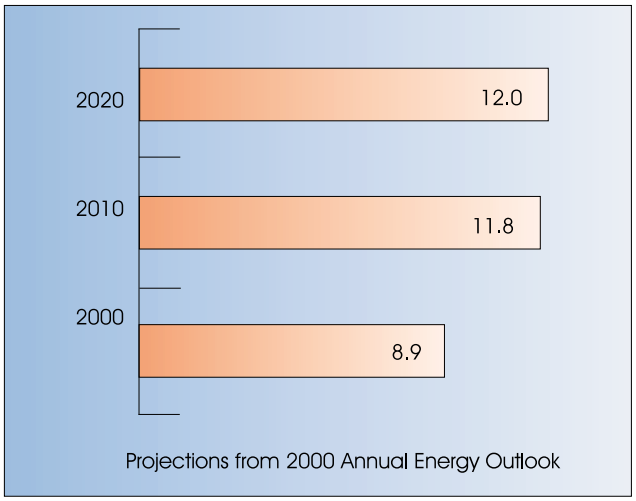
Figure 2: Worldwide Vehicle Registrations



Furthermore, the threat represented by this market volatility is exacerbated by the fact that the quality of conventional crude oil, with respect to sulfur content, also is expected to deteriorate in the future; this decline in quality will occur at the same time that the quality requirements for refined transportation fuels are becoming more stringent. Given current petroleum refining technologies, this quality gap between available feedstock and required product will compound the shortfall and market volatility of petroleum-based highway transportation fuels. It is urgent that advanced, cost-competitive petroleum refining technologies be developed to enable the production of higher quality fuels from lower quality petroleum crude.

Ultimately, a nation's energy security is proportional to its ability to produce the energy it requires from domestic feedstocks. In the case of its transportation sector, the United States is essentially dependent on petroleum and uses substantially more oil than is produced domestically. Furthermore, imports are projected to significantly increase in the future (see Figure 3). Highway transportation accounts for approximately 75 percent of all petroleum used in U.S. transportation, which is half of all the U.S. petroleum consumed on an annual basis. To enhance its energy security, the U.S. must establish a definitive process by which it can transition away from foreign petroleum and toward the primary use of domestic feedstocks for the production of its highway transportation fuels. A national priority must be placed on the R&D of advanced technologies and processes that will enable this country to utilize domestic heavy crude and alternate feedstocks, especially those fossil and biomass feedstocks that are abundantly available in the United States. Given the research nature of such an endeavor and the probable long lead time required to achieve success, this research must be conducted on an aggressive schedule.

Figure 3: Oil Imports



Environmental Concerns

In addition to the energy security threat inherent in continued dependence on petroleum as the dominant feedstock for transportation fuels, there are imminent national and global environmental consequences of major magnitude. At the national level, criteria pollutants play a major role in affecting ground level air quality. For example, of the total manmade air emissions in the U.S., highway transportation is responsible for 57 percent of the carbon monoxide (CO), 30 percent of the nitrogen oxides (NO_x), and 27 percent of the volatile organic compounds (VOC) (see Figure 4).

In response to this, the U.S. Environmental Protection Agency (EPA) Tier 2 emissions regulations for light-duty vehicles impose stricter limits on tailpipe emissions. Additionally, to meet the durability requirement imposed on emission control devices, the regulations will require significantly lower levels of sulfur content in fuels. The EPA has proposed regulations for heavy-duty engine emissions and diesel fuel quality that would be much stricter than current regulations.

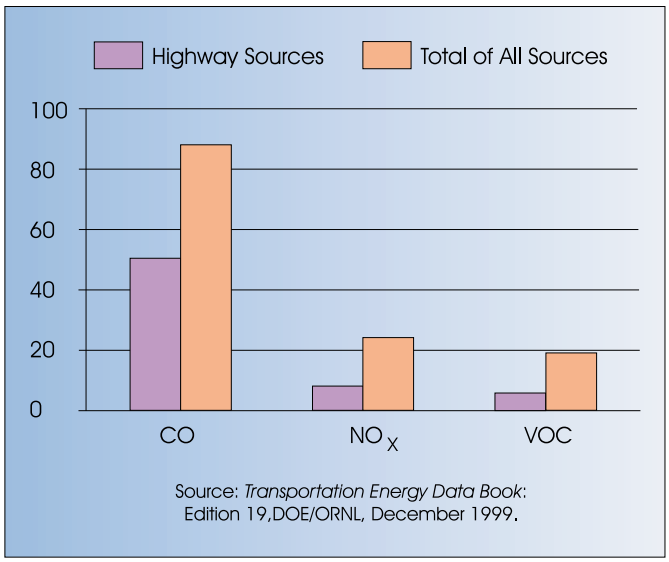
These stricter-than-anticipated emission control regulations, along with their timing, significantly increase the challenge and sense of urgency facing major government/industry initiatives aimed at developing high-efficiency highway vehicle technologies (e.g., PNGV, and 21st Century Truck Program). The timely success of these initiatives is critically dependent on the development of advanced, ultra-clean fuels that will enable the resulting technologies to achieve their dramatically improved levels of fuel economy while complying with current and anticipated environmental regulations and policies.

Globally, due to rapidly expanding petroleum-based transportation energy use, emissions of greenhouse gases (e.g., carbon dioxide) that contribute to climate perturbations are increasing. Highway transportation accounts for approximately 80 percent of total transportation emissions of carbon. The DOE Energy Information Agency projects that by 2020, total carbon emissions in the United States will increase to 1,975 million metric tons (MMT) under business-as-usual assumptions, with transportation petroleum combustion accounting for 665 MMT, or 34 percent of total U.S. carbon emissions. It is urgent that broad-based research be applied to the development of advanced fuels that will enable a reversal in the increasing rate of greenhouse gas production by highway transportation vehicles.

National Urgency

Collectively, the national security and environmental implications of the trends described above present a compelling case for establishing a robust, aggressive, technically-driven, collaborative government/industry program to develop: (1) a portfolio of ultra-clean highway transportation fuels that can be derived from domestic feedstocks, and (2) advanced technologies that will enable their commercial production and nationwide distribution.

Figure 4: Highway Emissions



Source: *Transportation Energy Data Book*: Edition 19,DOE/ORNL, December 1999.

Critical Needs

The critical need to reduce highway transportation-related air pollution, increase energy security, and minimize greenhouse gas emissions dictates that the UCTF Program undertake the following actions:

- Develop an integrated "systems approach" methodology to determine and predict the effects of interactions among the fuels-sensitive elements of engines and emissions control systems, and fuels on the performance of power systems.
- Reduce tailpipe emissions responsible for regional and urban air pollution to ultra-low levels by providing fuels having the characteristics, including low sulfur content, that provide for optimum engine performance and allow emissions control systems to perform effectively in advanced technology vehicles.
- Work with the petroleum industry to improve energy and process efficiency associated with the production of fuels. The result will be a highly efficient, flexible refinery that can produce a wider range of products from crudes of variable quality, as well as non-conventional feedstocks.
- Develop the technology base necessary to successfully upgrade poor feedstocks such as petroleum residuals and crude oil of inferior quality to meet stringent fuel specifications.
- Develop the technology base necessary to produce ultra-clean fuels from natural gas, coal, and carbonaceous wastes using processes that are compatible with carbon reduction and sequestration.
- Accelerate the development and deployment of cost-competitive biofuels for transportation via improved feedstock pretreatment, harvesting, fermentation, and enzyme system development.
- Develop databases and predictive models for performance of advanced, new, or reformulated fuels in advanced, high-efficiency vehicles.